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10/826,391	04/19/2004	Hideki Takahashi	252069US2	9709

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OBLON, SPIVAK, MCCLELLAND MAIER & NEUSTADT, P.C. 1940 DUKE STREET ALEXANDRIA, VA 22314		

EXAMINER	
LANDAU, MATTHEW C	

ART UNIT	PAPER NUMBER
2815	

NOTIFICATION DATE	DELIVERY MODE
10/24/2007	ELECTRONIC

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

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TH

**Office Action Summary**

Application No.

10/826,391

Applicant(s)

TAKAHASHI ET AL.

Examiner

Matthew C. Landau

Art Unit

2815

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --****Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 17 August 2007.
- 2a) ☒ This action is **FINAL**.                      2b) ☐ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 2-18 is/are pending in the application.
- 4a) Of the above claim(s) 7-12 and 16-18 is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 2-6 and 13-15 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All    b) ☐ Some \*    c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
  2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
  3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- |  |   |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892)                       | 4) <input type="checkbox"/> Interview Summary (PTO-413)           |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)   | Paper No(s)/Mail Date. _____                                      |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date <u>2/7/07, 6/1/07</u> .  | 6) <input type="checkbox"/> Other: _____                          |

## **DETAILED ACTION**

### ***Election/Restrictions***

Newly presented claim 18 reads on Figure 10, which corresponds to non-elected species II. Therefore, claims 7-12, and 16-18 are withdrawn from further consideration pursuant to 37 CFR 1.142(b), as being drawn to a nonelected invention or species, there being no allowable generic or linking claim. Applicant timely traversed the restriction (election) requirement in the reply filed on July 5, 2005.

### ***Claim Rejections - 35 USC § 103***

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

Claims 2, 3, 6, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sakurai (US Pat. 5,270,230) in view of Tanaka (US PGPub 2001/0040255).

Regarding claims 2 and 3, Figure 3 of Sakurai discloses an insulated gate bipolar transistor (IGBT) comprising: a semiconductor substrate of a first conductivity type (n-type) including a first main surface (top surface) and a second main surface (bottom surface); an insulated gate transistor 6/7 formed in a region of said substrate on a side of said semiconductor substrate where said first main surface is included, said insulated gate transistor including a

channel of said first conductivity type which is formed within a base region 4 of a second conductivity type (p-type) during an on state of said insulated gate transistor, said base region extending from said first main surface toward an interior of said substrate; a first main electrode 9 formed on said first main surface and being in contact with said base region of said insulated gate transistor at said first main surface; a first semiconductor layer 2 of said first conductivity type formed on said second main surface of said semiconductor substrate, facing said insulated gate transistor, and vertically aligned with a region of the first main electrode 9 in contact with said base region 4 (as clearly shown in Fig. 3); a second semiconductor layer 1 of said second conductivity type formed on said second main surface of said substrate and facing said insulated gate transistor; and a second main electrode 10 formed on said first semiconductor layer and said second semiconductor layer, wherein an interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer is parallel to said first main surface, a distance between said first main surface and said interface is equal to 200  $\mu\text{m}$ , a first interface between said first semiconductor layer and said second main electrode occupies 20-70% of said interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer, and a second interface between said second semiconductor layer and said second main electrode occupies 30-80% of said interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer. Note that Figure 3 of Sakurai shows the interface of the first semiconductor layer 2 occupies approximately 50% of the total area. The difference between Sakurai and the claimed invention is a thickness of each of said first semiconductor layer and said second semiconductor layer is equal to 2  $\mu\text{m}$  or smaller. Figure 10 of Tanaka discloses an IGBT with

first and second semiconductor regions (12 and 2B, respectively) in a second main surface of a semiconductor substrate 1, wherein the thickness of the second semiconductor region 2B is less than 1 micron (approximately 0.8 microns) (paragraph [0187]). As shown in Figure 10, region 12 is thinner than region 2B, therefore the first semiconductor region 12 is also less than 1 microns. In view of such teaching, it would have been obvious to the ordinary artisan at the time the invention was made to modify the invention of Sakurai by using a thickness of less than 1 micron for the first and second semiconductor regions as taught by Tanaka. The ordinary artisan would have been motivated to modify Sakurai in the manner described above for the purpose of reducing the carrier injection coefficient and increasing the turn-off speed of the device (paragraph [0190] of Tanaka).

Regarding claims 6 and 15, Figure 3 of Sakurai discloses said IGBT functions as a switching device with a built-in freewheeling diode. Note that it is inherent that the device shown in Figure 3 of Sakurai has a freewheeling diode since it has the same structure as Figure 2 of the instant application, which is disclosed as having a built-in freewheeling diode (page 14, line 10 – page 15, line 2).

Claims 4 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sakurai in view of Tanaka as applied to claims 2 and 3 above, and as evidenced by Akiyama et al. (“Effects of Shorted...”, hereinafter Akiyama).

Regarding claims 4 and 13, a further difference between Sakurai and the claimed invention is a total width of a first width of said first semiconductor layer and a second width of

said second semiconductor layer which are parallel to said first main surface and extend along a direction in which said first semiconductor layer and said second semiconductor layer are aligned is in a range from 50  $\mu\text{m}$  to 200  $\mu\text{m}$ . However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Sakurai to have a total width within the claimed range, since it has been held that discovering an optimum value of a result effective variable involves only routine skill in the art. *In re Boesch*, 617 F.2d 272, 205 USPQ 215 (CCPA 1980). Figure 1a and 3 and Table 1 of Akima disclose varying the widths of the semiconductor layers in contact with the collector electrode affects device parameters (such as on-state voltage). Akima demonstrates the total width of the first and second semiconductor layers is recognized in the art as a result effective variable. Since no evidence of unexpected results has been provided, the claimed range is held to be obvious.

Claims 5 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sakurai in view of Tanaka as applied to claims 2 and 3 above, and further in view of Reznik (US Pat. 6,798,040).

Regarding claims 5 and 14, a further difference between Sakurai and the claimed invention is an additional semiconductor layer of said first conductivity type which extends from an interface between said base region and said semiconductor substrate toward said interior of said semiconductor substrate, and an impurity concentration of said additional semiconductor layer is higher than that of a portion of said semiconductor substrate which forms an interface with said additional semiconductor layer. Figure 1 of Reznik discloses an IGBT with an

additional semiconductor layer (buffer layer) 6 between the semiconductor substrate 1 and the base region 4, wherein the impurity concentration of layer 6 is greater than that of the substrate 1. In view of such teaching, it would have been obvious to the ordinary artisan at the time the invention was made to further modify the invention of Sakurai by including the additional semiconductor layer (buffer layer) of Reznik for the purpose of elevating the charge carrier density in the region, thereby reducing the switching losses (col. 3, lines 4-8).

Claims 2, 3, 6, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matsudai et al. (US PGPub 2002/0048855, hereinafter Matsudai) in view of Tanaka.

Regarding claims 2 and 3, Figure 2 of Matsudai discloses an IGBT comprising: a semiconductor substrate 11 of a first conductivity type (n-type) including a first main surface (top surface) and a second main surface (bottom surface); an insulated gate transistor 20/19A formed in a region of said substrate on a side of said semiconductor substrate where said first main surface is included, said insulated gate transistor including a channel of said first conductivity type which is formed within a base region 14/16 of a second conductivity type (p-type) during an on state of said insulated gate transistor, said base region extending from said first main surface toward an interior of said substrate; a first main electrode 18 formed on said first main surface and being in contact with said base region of said insulated gate transistor at said first main surface; a second semiconductor layer 10 of said second conductivity type formed on said second main surface of said semiconductor substrate and facing said insulated gate

transistor; and a second main electrode 21 formed on said first semiconductor layer and said second semiconductor layer, wherein an interface between said second main electrode and said second semiconductor layer is parallel to said first main surface, a distance between said first main surface and said interface is less than 200  $\mu\text{m}$ , and a thickness of the second semiconductor layer is less than 2  $\mu\text{m}$ . Note that Matsudai discloses region 10 is 1.0  $\mu\text{m}$  thick (paragraph [0050]), region 12 is 15  $\mu\text{m}$  thick (paragraph [0059]), region 13 is 52.5  $\mu\text{m}$  thick (paragraph [0059]), and region 17 is 4.5  $\mu\text{m}$  thick (paragraph [0062]). Therefore, the total thickness is less than 200  $\mu\text{m}$ . The difference between Matsudai and the claimed invention is an n-type first semiconductor layer formed on the second surface of the substrate and vertically aligned with a region of the first main electrode in contact with said base region, wherein a thickness of each of the first and second semiconductor layers is equal to 2  $\mu\text{m}$  or smaller, a first interface between said first semiconductor layer and said second main electrode occupies 20-70% of said interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer, and a second interface between said second semiconductor layer and said second main electrode occupies 30-80% of said interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer. Figure 10 of Tanaka discloses an IGBT with first semiconductor regions 12 (n-type) and second semiconductor regions 2B (p-type) in a second main surface of a semiconductor substrate 1, wherein first semiconductor layer 12 is vertically aligned (at least partially) with a region of the first main electrode 11 in contact with said base region 7, and wherein the thickness of the second semiconductor region 2B is less than 1 micron (approximately 0.8 microns) (paragraph [0187]). As shown in Figure 10, region 12 is thinner



than region 2B, therefore the first semiconductor region 12 is also less than 1 microns. Figure 10 of Tanaka also discloses a first interface between said first semiconductor layer 12 and electrode 3 occupies approximately 20-70% of interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer; and a second interface between said second semiconductor layer 2B and said electrode 3 occupies approximately 30-80% of said interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer. In view of such teaching, it would have been obvious to the ordinary artisan at the time the invention was made to modify the invention of Matsudai by using first and second semiconductor regions with thickness of less than 1 micron and the specified width as taught by Tanaka. The ordinary artisan would have been motivated to modify Matsudai in the manner described above for the purpose of reducing the carrier injection coefficient and increasing the turn-off speed of the device (paragraph [0190] of Tanaka). It would have been further obvious to have the first semiconductor region vertically aligned with a region of the first main electrode in contact with the base region as taught by Tanaka in order to allow a direct current path between the base region and first semiconductor layer.

Regarding claims 6 and 15, after the above combination, the IGBT of Matsudai and Tanaka functions as a switching device with a built-in freewheeling diode. Note that it is inherent that the device of the above combination has a freewheeling diode since it has the same structure as Figure 2 of the instant application, which is disclosed as having a built-in freewheeling diode (page 14, line 10 – page 15, line 2).

Claims 4 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matsudai in view of Tanaka as applied to claims 2 and 3 above, and as evidenced by Akiyama et al. ("Effects of Shorted...", hereinafter Akiyama).

Regarding claims 4 and 13, a further difference between Matsudai and the claimed invention is a total width of a first width of said first semiconductor layer and a second width of said second semiconductor layer which are parallel to said first main surface and extend along a direction in which said first semiconductor layer and said second semiconductor layer are aligned is in a range from 50  $\mu\text{m}$  to 200  $\mu\text{m}$ . However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Matsudai to have a total width within the claimed range, since it has been held that discovering an optimum value of a result effective variable involves only routine skill in the art. *In re Boesch*, 617 F.2d 272, 205 USPQ 215 (CCPA 1980). Figure 1a and 3 and Table 1 of Akima disclose varying the widths of the semiconductor layers in contact with the collector electrode affects device parameters (such as on-state voltage). Akima demonstrates the total width of the first and second semiconductor layers is recognized in the art as a result effective variable. Since no evidence of unexpected results has been provided, the claimed range is held to be obvious.

Claims 5 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matsudai in view of Tanaka as applied to claims 2 and 3 above, and further in view of Reznik (US Pat. 6,798,040).

Regarding claims 5 and 14, a further difference between Matsudai and the claimed invention is an additional semiconductor layer of said first conductivity type which extends from an interface between said base region and said semiconductor substrate toward said interior of said semiconductor substrate, and an impurity concentration of said additional semiconductor layer is higher than that of a portion of said semiconductor substrate which forms an interface with said additional semiconductor layer. Figure 1 of Reznik discloses an IGBT with an additional semiconductor layer (buffer layer) 6 between the semiconductor substrate 1 and the base region 4, wherein the impurity concentration of layer 6 is greater than that of the substrate 1. In view of such teaching, it would have been obvious to the ordinary artisan at the time the invention was made to further modify the invention of Matsudai by including the additional semiconductor layer (buffer layer) of Reznik for the purpose of elevating the charge carrier density in the region, thereby reducing the switching losses (col. 3, lines 4-8).

Claims 2, 3, 6, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tanaka in view of Sakurai.

Regarding claims 2 and 3, Figure 10 of Tanaka discloses an insulated gate bipolar transistor (IGBT) comprising: a semiconductor substrate 1 of a first conductivity type (n-type) including a first main surface (top surface) and a second main surface (bottom); an insulated gate transistor formed in a region of said semiconductor substrate on a side of said semiconductor substrate where said first main surface is included, said insulated gate transistor including a

channel of said first conductivity type which is formed within a base region 7 of a second conductivity type (p-type) during an on state of said insulated gate transistor, said base region extending from said first main surface toward an interior of said semiconductor substrate; a first main electrode 11 formed on said first main surface and being in contact with said base region of said insulated gate transistor at said first main surface; a first semiconductor layer 12 of said first conductivity type formed on said second main surface of said semiconductor substrate, facing said insulated gate transistor, and vertically aligned (at least partially) with a region of the first main electrode 11 in contact with said base region 7 ; a second semiconductor layer 2B of said second conductivity type formed on said second main surface of said semiconductor substrate and facing said insulated gate transistor; a second main electrode 3 formed on said first semiconductor layer and said second semiconductor layer; wherein an interface between said second main electrode and each of said first and second semiconductor layers is parallel to said first main surface, a thickness of each of said first semiconductor layer and said second semiconductor layer is equal to 2 microns or smaller (0.8 microns) (paragraph [0187]); a first interface between said first semiconductor layer 12 and said second main electrode 3 occupies approximately 20-70% of said interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer; and a second interface between said second semiconductor layer 2B and said second main electrode 3 occupies approximately 30-80% of said interface between said second main electrode and each of said first semiconductor layer and said second semiconductor layer. Tanaka does not specifically disclose a distance between said first main surface and said interface is equal to 200 microns or smaller. Figure 3 of Sakurai discloses an IGBT with a substrate thickness of 200  $\mu\text{m}$ . In view of such

teaching, it would have been obvious to the ordinary artisan at the time the invention was made to modify the invention of Tanaka by using the substrate thickness of 200  $\mu\text{m}$  as taught by Sakurai for the purpose of selecting a thin substrate, allowing for a thin drift region.

Alternatively, it would have been obvious to one having ordinary skill in the art at the time the invention was made to have a distance between the first surface and the interface equal to or less than 200 microns, since it has been held that discovering an optimum value of a result effective variable involves only routine skill in the art. *In re Boesch*, 617 F.2d 272, 205 USPQ 215 (CCPA 1980). The disclosure of Sakurai is evidence that the thickness of the substrate is a result effective variable (see col. 2, lines 47-51).

Regarding claims 6 and 15, Figure 10 of Tanaka discloses said IGBT functions as a switching device with a built-in freewheeling diode. Note that it is inherent that the device shown in Figure 10 of Tanaka has a freewheeling diode since it has the same structure as Figure 2 of the instant application, which is disclosed as having a built-in freewheeling diode (page 14, line 10 – page 15, line 2).

Claims 4 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Tanaka in view of Sakurai as applied to claims 2 and 3 above, and as evidenced by Akiyama et al. (“Effects of Shorted...”, hereinafter Akiyama).

Regarding claims 4 and 13, a further difference between Tanaka and the claimed invention is a total width of a first width of said first semiconductor layer and a second width of said second semiconductor layer which are parallel to said first main surface and extend along a

direction in which said first semiconductor layer and said second semiconductor layer are aligned is in a range from 50  $\mu\text{m}$  to 200  $\mu\text{m}$ . However, it would have been obvious to one having ordinary skill in the art at the time the invention was made to modify Tanaka to have a total width within the claimed range, since it has been held that discovering an optimum value of a result effective variable involves only routine skill in the art. *In re Boesch*, 617 F.2d 272, 205 USPQ 215 (CCPA 1980). Figure 1a and 3 and Table 1 of Akima disclose varying the widths of the semiconductor layers in contact with the collector electrode affects device parameters (such as on-state voltage). Akima demonstrates the total width of the first and second semiconductor layers is recognized in the art as a result effective variable. Since no evidence of unexpected results has been provided, the claimed range is held to be obvious.

Claims 5 and 14 are rejected under 35 U.S.C. 103(a) as being unpatentable over Matsudai in view of Tanaka as applied to claim 2 and 3 above, and further in view of Reznik (US Pat. 6,798,040).

Regarding claims 5 and 14, a further difference between Tanaka and the claimed invention is an additional semiconductor layer of said first conductivity type which extends from an interface between said base region and said semiconductor substrate toward said interior of said semiconductor substrate, and an impurity concentration of said additional semiconductor layer is higher than that of a portion of said semiconductor substrate which forms an interface with said additional semiconductor layer. Figure 1 of Reznik discloses an IGBT with an additional semiconductor layer (buffer layer) 6 between the semiconductor substrate 1 and the

base region 4, wherein the impurity concentration of layer 6 is greater than that of the substrate

1. In view of such teaching, it would have been obvious to the ordinary artisan at the time the invention was made to further modify the invention of Tanaka by including the additional semiconductor layer (buffer layer) of Reznik for the purpose of elevating the charge carrier density in the region, thereby reducing the switching losses (col. 3, lines 4-8).

### ***Response to Arguments***

Applicant's arguments filed May 7, 2007 have been fully considered but they are not persuasive.

Applicant argues that none of the references of record teach the newly added limitation which requires the first semiconductor layer to be vertically aligned with a region of the first main electrode in contact with said base region. However, as indicated in the above rejection, both Sakurai and Tanaka teach this limitation. Figure 3 of Sakurai clearly shows the first semiconductor layer 2 is directly below, and therefore vertically aligned with the base region 4 and a region of the first main electrode 9 in contact with the base region. Also, Figure 10 of Tanaka clearly shows the first semiconductor layer 12 is directly below, and therefore vertically aligned (at least partially) with the base region 7 and a region of the first main electrode 11 in contact with the base region.

### ***Conclusion***

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire **THREE MONTHS** from the mailing date of this action. In the event a first reply is filed within **TWO MONTHS** of the mailing date of this final action and the advisory action is not mailed until after the end of the **THREE-MONTH** shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than **SIX MONTHS** from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Matthew C. Landau whose telephone number is 571-272-1731. The examiner can normally be reached on 9:00AM - 5:30PM.

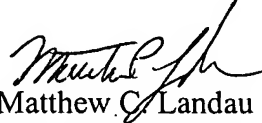
If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Ken Parker can be reached on 571-272-2298. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.



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Matthew C. Landau  
Primary Examiner  
Art Unit 2815